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USMC AVIATION VISION 2025 AND THE MISDIRECTION OF AIRBORNE ELECTRONIC WARFARE

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Executive Summary

Title: USMC Aviation Vision 2025 and the Misdirection of Airborne Electronic Warfare.

Author: Major Robert Kudelko, United States Marine Corps

Thesis: The Marine Corps plan to eliminate a tactical aircraft dedicated to the mission of electronic warfare as well as the increased emphasis on unmanned systems to conduct the EW mission will leave the Marine Corps significantly unprepared to deal with both current and emerging RF threats to MAGTF operations.

Discussion: The Marine Aviation Campaign Plan is a modernization program that will eliminate all legacy aircraft and streamline all tactical aircraft to the F-35 Joint Strike Fighter. Among the aircraft being eliminated is the EA-6B, the nation's only dedicated tactical airborne electronic warfare aircraft. As a replacement to the EA-6B, the Marines propose F-35s and unmanned systems equipped with jammers to fill the need for airborne EW. This solution does not adequately address the limitations of those two systems or the support needs of future platforms like the MV-22 and the Expeditionary Fighting Vehicle. These new vehicles will allow MAGTF commanders to project forces farther ashore and operate in an environment increasingly vulnerable to enemy radar guided threats. Unmanned systems planned to fill EW requirements do not have the lift capacity to carry high powered jammers and do not have the range to operate ashore from sea-based expeditionary vessels. Unmanned systems also have a higher loss rate than do conventional aircraft, making their payloads vulnerable to enemy capture and exploitation. The Marine Corps needs to re-evaluate their road ahead regarding EW requirements in order to ensure that the capability that they desire is, in fact, the capability that they are purchasing.

Conclusion: The Marine Corps of 2025 will be capable of conducting electronic warfare with both the F-35 and its UASs. What it will not have is the speed, flexibility and versatility that the Marines have come to expect from their current airborne EW platform, the EA-6B, which is the type of system that will be needed to support future expeditionary operations.

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE MARINE CORPS COMMAND AND STAFF COLLEGE OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

Preface

This project is the manifestation of several years of frustration born out of constant indecision regarding the future of aviation electronic warfare in the Marine Corps. As an EW operator, I have been witness to numerous conferences in which the Marine Corps has attempted to lay out a roadmap for the future. In most of these meetings, the attendees are resigned to the understanding that the EA-6B community is a stepchild within Marine Aviation and most EW related decisions are made outside of he Marine Corps. The complication lies in the fact that 'Big Navy' often determines the funding/procurement of tactical aircraft and the 'National Asset' label attached to EA-6B's makes us outsiders within our own service. While the Marine Corps enters a new era of V-22's, Expeditionary Fighting Vehicles and Joint Strike Fighters, we are not keeping up with our obligation to protect those systems. My aircraft, the EA-6B, will retire in 2019 after nearly 45 years of service and I do not believe that the Marine Corps is poised to address the RF threat when that occurs.

I would like to thank Col Wakeman and GySgt Gonzalez for the assistance they provided me in my research. The materials and insight they gave me on the Joint Strike Fighter program and Unmanned Airborne Sensor programs were valuable to my research. I would also like to thank the current and previous directors of the Marine Aviation Weapons Requirements (EW) division at Headquarters Marine Corps. Their tireless dedication to promoting tactical electronic warfare that is relevant to the future Marine Corps is what inspired my decision to write this thesis.

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INTRODUCTION

In the summer of 2008, Marine Corps Commandant General James Conway released the publication *Marine Corps Vision & Strategy 2025*. The commandant stressed the point that "Marine Aviation will continue to provide six functions to the MAGTF." Those six functions being: assault support, anti air warfare (AAW), offensive air support (OAS), control of aircraft and missiles, aerial reconnaissance and electronic warfare (EW). Between now and 2025, Marine Aviation will undergo numerous changes. The Marine Aviation Transition Strategy is designed to replace and upgrade every major aircraft type in the inventory with next generation capability.

Presently the medium lift helicopter community is undergoing the replacement of its fifteen Vietnam era CH-46 helicopter squadrons with the tilt-rotor MV-22. This transition will be complete within the next ten years.* Both the VSTOL attack jet AV-8B and multi-role FA-18 will eventually be replaced by the F-35 Joint Strike Fighter (JSF). The fighter/attack transition to JSF is underway with an initial operational capability (IOC) date of 2012 and completion by 2024. The EA-6B Prowler, the world's only tactical electronic attack jet, will be retired outright. The EA-6B will begin its drawdown in 2016 and be retired from service at the end of 2019. When the Prowler retires, it will mark the end of the Marine Corps' only dedicated aviation electronic attack platform.

The question that must be asked is: when the Prowler retires, how will Marine Aviation counter the radio frequency (RF) threat of the future and adequately support the MAGTF? That single question is made up of three parts: threat, capability, and platform. What is the future electronic threat to the MAGTF? What EW capability does the Marine Corps need in order to accomplish its mission? What platform is most suitable for providing that capability at and

* At the end of 2008, four CH-46 squadrons had completed transition to MV-22.

beyond 2025? Optimally, the answers to the first two questions drive the third. Unfortunately, in the complex and budget driven world of weapons procurement, development is not always so linear.

Circumstances like this have helped to shape the Marines' aviation transition strategy, and this paper will investigate platform suitability as the first topic. From there I will discuss areas where Marine missions will likely be in need of EW capabilities. Finally, I will cover the limited capabilities Marine air has in countering the RF threat.

PLATFORM SUITABILITY

What form must an EW platform come in to support the MAGTF commander? The Vision 2025 document is heavily laden with an expeditionary theme. The future Marine Corps "will be increasingly reliant on naval deployment . . . leaner in equipment, versatile in capabilities, and innovative in mindset."[1] The transformation of Marine air will provide it with "greater range, speed and agility" and the associated technology will be "driving new concepts of operation to the MAGTF."[2] Unmanned systems are specifically charged with "enhance[ing] and extend[ing] the lethal and non lethal capability of the MAGTF."[3] These statements, along with the Tactical Aircraft Integration Plan and eventual Joint Strike Fighter transition give a pretty good guidance as to the desired shape of things to come. The future of Marine aviation is streamlined, multi-functional, and expeditionary.

Despite all of its strengths, the EA-6Bs major fault is its limited availability (quantity) and its lack of a true expeditionary capability. Prowlers cannot deploy aboard amphibious shipping like the STOVL capable AV-8B. The various jamming pods necessary for different mission requirements give the Prowler a large logistic foot print. The Prowler was never

manufactured in significant numbers to meet the high sortie rates necessary to support sustained ground operations.* Finally, the limited numbers of aircraft needed to fill high priority missions often results in tasking originating above the MAGTF commanders level. This tasking often results in the MAGTF commander having to appeal to a Joint or Combined Forces Air Component Commander (J/CFACC) in order to source any aviation EW. This situation is frequently referred to as "low density, high demand." Any new platform would ideally be accessible to a MEU level commander and ideally would be capable of operating from a ship within the Amphibious Strike Group. Meeting these requirements while still complying with the Commandant's aviation campaign plan implies that the electronic warfare capability will have to reside among multiple types of aircraft. In 2025, those platforms will be Unmanned Systems, Fixed Wing (F-35, KC-130J), and Tilt/Rotary Wing (V-22, AH-1, CH-53).

JOINT STRIKE FIGHTER

The most abundant of these platforms will be the F-35B. This is the VSTOL variant of the Joint Strike Fighter. The Marine Corps plans on purchasing over three-hundred of these aircraft by FY 2023. It is certainly possible that the Joint Strike Fighter will be capable of filling some of the more traditional mission sets that the Prowler once provided. Originally designed as a cold war weapon, the Prowler mission was focused on suppressing Soviet style enemy air defense networks. The Prowler facilitated other strike aircraft in attacking targets deep behind enemy lines. The F-35, having both low observable characteristics and a powerful jamming capability will enable it to penetrate enemy defenses without external support. Over the years however, the Prowler mission has expanded greatly to include extensive communications

* EA-6Bs are currently flying between two and five times their programmed utilization rates in support of operations in Iraq and Afghanistan.

jamming, force protection missions, and other dimensions within Information Operations such as Psychological Operations (see App C). It is in these newer mission sets that aviation electronic warfare has made itself not just valuable to the ground combat element but a sought after capability. The nature of warfare has evolved to the point where the MAGTF commander wants EW coverage in direct support of his ground scheme of maneuver just as much as he wants artillery and close air support. That demand is drawing attention away from the air and coastal defense threats and towards the low tech, ground oriented devices that we are encountering in Iraq and Afghanistan today. The Marine Corps proposal to make airborne EW more access able to more Marines on the ground is through the use of numerous unmanned systems.

UNMANNED VEHICLES

Marine Corps Unmanned Aerial Systems concept of employment is structured in a three tier system, each coinciding with the level of command they support. Tier I is considered a battalion level or below asset, Tier II is a division, regiment, battalion, or MEU asset. Tier III is assigned to the Joint Task Force/MAGTF commander.[4]

The Tier I system for the Marine Corps is the Dragon-Eye with an eventual upgrade to the Raven-B. Problems observed with these smaller systems are their susceptibility to weather, wind and turbulence. Furthermore, sensor quality suffers because these smaller airframes are more sensitive to vibrations and are more vulnerable to gusting winds and environmentals noted above. Vibration and instability are poor characteristics of an EW platform. A stable platform is needed for accurate radio frequency (RF) direction finding (DF) associated with Electronic Warfare Support missions as well as a requirement for jammer steering stabilization conducting Electronic Attack missions.

The Marine Corps does not currently have a program of record for a Tier II UAS but mission requirements are being filled by the Scan Eagle. The Scan Eagle is a temporary contract being supported by Boeing while a joint service program of record is developed.

The largest and most capable of Marine Corps UASs is the Tier III level RQ-7B Shadow. The Shadow has a range of 27 miles, a payload of 60 pounds and a maximum speed of about 100 knots.[5] Like its smaller cousins, the Shadow is similarly restricted by environmental conditions such as rain and visible moisture and can only survive up to light category turbulence. The limited range of the Shadow is only due to its line of site control and video data link.* Relatively simple upgrades with existing satellite data link technology would enable over-the-horizon capability that would be necessary to execute certain EW missions. The payload capacity has been sufficient for specialized Electronic Attack missions but that system (the Pioneer Electronic Attack Payload) is very low power, cannot be reprogrammed in flight and the vehicle has no intelligence/surveillance/reconnaissance (ISR) capability when configured for EA.

The combined lack of speed and modest endurance of 4 hrs affords very little flexibility in the construct of expeditionary warfare. The USMC systems have provided dedicated support for sustained combat operations in both Iraq and Afghanistan but they are no more expeditionary than a conventional FA-18 or EA-6B squadron when it comes to runway requirements and logistics. The Pioneer was originally designed with the capability to launch via catapult and recover via net but employment of both techniques (particularly recovery) resulted in unacceptable damage to both the airframe and the sensitive payload aboard. Conventional Pioneer runway requirements call for 2000 feet of improved surface. A *Tarawa* class LHA (helicopter assault landing craft) has an 820 foot long flight deck and the future *America* class

* Line-of-site is defined as the straight line distance between two items (such as a radio transmitter and a radio receiver). This line must be unobstructed by any natural or manmade obstacles.

LHA is planned to have an 844 foot long flight deck. Any desire to launch or recover unmanned systems aboard ship would require a more suitable method for launch and recovery. Additionally, the guidance/control method needs to be capable of operating aboard ship without occupying excessive space.*

MISSION PAYLOAD

The driving factor behind the size of a suitable UAS is the size of the EW payload itself. The current configuration for airborne electronic attack is the ALQ-99 Tactical Jamming System carried by the EA-6B. Each ALQ-99 jamming pod is 15 ft long and weighs about 1000 lbs. Each pod is specially configured to jam a specific block of frequencies depending on mission requirements. A combat configuration for a Prowler typically consists of three or four jamming pods. Another unique but effective EW weapon in the arsenal is the ALE-43 bulk chaff pod. Chaff is a cloud of aluminum fibers that reflect radar signals and present false targets on radar scopes. Chaff is used to screen, deceive and protect friendly forces from enemy radar detection and targeting. Bulk chaff is proven effective against most older radar systems and has even shown success against some modern phased-array radars as well. A single roll of type RR-144 bulk chaff weighs 50lbs and the whole ALE-43 system (with eight rolls of chaff) tops 800lbs. One of the standard electronic attack weapons is the AGM-88 High Speed Anti Radiation Missile (HARM). This specialized missile has been a staple of the suppression of enemy air defense (SEAD) missions since 1984 and will likely be the only US anti-radiation weapon in the inventory for the next ten years. Weighing in at 800 lbs and measuring 13 feet in length, the HARM would burden most unmanned platforms with its bulk and targeting system requirements.

* The Shadow 200 does have a catapult launch system however recovery method is via conventional runway landing with hook arrestment.

Plans to integrate the HARM into FA-18G and F-35 ensure that the size and weight of anti radiation weapons will remain largely unchanged for many years.*

Either the bulk chaff mission or the anti-radiation missile missions could be configured as a single, specialized payload for a future UAS but offensive jammers remain a more difficult challenge. Issues such as system weight, aircraft positioning and dynamic responsiveness all suggest a better solution than the UAS. "From Lockheed Martin's viewpoint, the use of unmanned aerial vehicles and disposable jammers does not nullify the need for an electronic attack version of the F-35. When it comes to working in a tightly integrated fashion with the strike formation, we think the group can best provide their own organic support."[6]

Technological advances often result in smaller, lighter components and systems. This has certainly been the case with radios, GPS receivers and even radar systems. The ALQ-99 system was originally developed in the 1970's and has largely gone unchanged since them. One would assume that engineers could produce a smaller, lighter jammer with better capabilities. Unfortunately, design constraints for a tactical pod that is both high powered and properly cooled while still maintaining proper aerodynamics is yielding rather large results. "There are some very basic physics behind it that require large amounts of power which require large sources to produce that power which require big, heavy pieces of equipment."[7] Both the Air Force and the Navy have been pursuing jammer projects that would fill the pending EA gap that will exist when EA-6Bs retire. Both projects are large and heavy. The Air Force plan was leaning towards a 40ft long, five thousand pound pod that was to be mounted on a B-52 or C-130 sized aircraft. The employment profile would be a high altitude orbit far outside the reach of enemy surface to air threat systems.[8] This program was cancelled in 2005, revived in 2007 and cancelled again in

* The Advanced Anti-Radiation Guided Missile (AARGM) is a proposed upgrade to the HARM but does not change the physical dimensions of the weapon.

January of 2009. The reason for its cancellation was due to budget estimates in the billions of dollars. The indecision on this project highlights three things: One, the Air Force is very concerned over the impending degradation of tactical EA capabilities. The second is that few electronic warfare options are readily available and the third is that none of the solutions are cheap. Even with a revised plan of leveraging existing technology, the Air Force pod was not slated to be operational until close to the year 2020.

On January 18th, 2009, the Navy awarded four $5.5 million contracts for research and support in developing the Next Generation Jammer.[9] The new jammer is planned to enter service in 2018. The pod design is still only a concept but early theories suggest that it will resembles the ALQ-99 system in both size and weight. The Next Gen Jammer is intended to replace the ALQ-99 system on its EA-18G electronic attack Hornets and has recently been is been added to the requirements for F-35 compatibility as well.[10]

In either case, carrying the Next Gen jammer would limit that respective airframe to an EW mission only with little room or weapon stations available for Offensive Air Support or Anti Air Warfare weapons. The significance of this matter will be discussed in further detail in the Mission Requirements section of this paper.

A potential solution to dealing with the size of the jammers is the KC-130J. The KC-130J is a large, heavy lift aircraft that has great endurance and a self-deployment capability.* They exist in fairly large numbers (46 operational and another 33 planned for production) and currently deploy in support of MEU operations. While not deployable aboard an LHA, their range and endurance allow them to support MAGTF operations by flying out of the closest suitable airfield.

* Self-deployment refers to the C-130s capability to carry all necessary tools and spare parts necessary for the aircraft to operate away from its home station.

Right now, the unmanned system most capable of assuming an EW mission is the US Air Force RQ-9 Predator/ Reaper family. With a payload capacity of 3,000 lbs externally and another 800 lbs internally, the Predator could possibly carry two Next Gen type jammer pods into combat or one pod and one kinetic style weapon. The main drawback to the RQ-9 is that its wingspan of 66 feet makes it larger than most of our current TacAir platforms and the airframe is not sturdy enough for shipboard recovery. However, with its exceptionally long range (3,200nm) an RQ-9 could easily deploy like (or even with) KC-130s in support of MEU operations. It could serve in an 'on call' role and deploy upon request offering greater flexibility than a squadron of conventional aircraft could provide. The long range of the system is due to the satellite data link. The RQ-9 Predator has essentially an unlimited range via satellite data link and a total internal/external payload capacity of just shy of 4,000 lbs. making it capable of lifting all of the weapons/equipment utilized by the EA-6B.

The Marine aviation weapon systems requirements division (APW) has been working on a system they are calling the Jammer Cube. The Jammer Cube is a 1 kilowatt (kW) jammer that barely weighs three pounds and is the size of several stacked CD cases. After adding an amplifier and conformal antennas, the system weight should be just over eleven pounds. Such a device could be integrated into a Tier III UAS but a 1kW jammer has a very limited application against communication systems and virtually none against radars. Commercial off the shelf communications like the Senao 258 long range cordless telephone (a system commonly found in Iraq) also operates at 1kW power. With equal power outputs between the jammer and the communication system, proximity of that jammer to the target receiver is of critical importance in order to have the desired effects.* Information of this sort is very dependent on intelligence

* Jam to Signal ratio (J/S) is the ratio of the jamming signal strength to the strength of the desired signal. When jamming two way communications, the receiver radio/antenna is the target of the jamming.

support. Military search radars operate in excess of 300kW and produce wave-forms more complex than most communications systems. A recent interview with the EW project manager at APW revealed that the Jammer Cube has encountered funding issues that will delay any further development until at least the summer/fall of 2009.[11]

SURVIVABILITY

Assuming that size/weight issues can be overcome a very serious consideration must be given to survivability of the platform and security of the sensitive equipment on board. Each ALQ-99 pod cost approximately $1 million and houses classified electronic equipment. An Air Force study published in 2008 reported that the "Predator's mishap rate is far higher than for 'mature' aircraft such as the F-16 and F-15." [12] According to the U.S. Air Force accident investigation board, there were eight RQ/MQ-1 Class A's in FY-08. All of the mishaps occurred supporting combat operations. Of the six completed investigations, one aircraft was recovered, three were destroyed in place (by EOD or air) and two airframes were never recovered. In a 2006 report issued to the House Armed Services Committee, the Marine Corps stated that 23 Pioneer 'incidents' and five 'strikes' occurred in the first eight months of OIF[13]. This equated to one vehicle completely stricken from the inventory for every 471.6 flight hours. If EA-6Bs suffered the same incident rate, that would wipe out an entire squadron every six months. While the Marine UAS losses have declined significantly over the years, evidence still suggests that unmanned aircraft offer far less security to classified equipment than manned.

The issue here is not the money but rather the security of our technology. Unmanned systems are intended to be a more cost effective way of conducting dangerous or mundane missions. How does national security factor in to cost/benefit analysis? How many EW

payloads are we willing to lose before we should consider the technology to have been exploited by the enemy?

MISSION REQUIREMENTS

O'GRADY TRAP MISSION

One of the most high profile military events of the mid 90's was the rescue of U.S. Air Force Captain Scott O'Grady. Capt O'Grady was an F-16 pilot shot down by a radar guided surface to air missile while enforcing a UN no-fly zone over the skies of Serbia in June of 1995. The 24th Marine Expeditionary Unit- Special Operations Capable (MEU[SOC]) was called upon to execute a TRAP (Tactical Recovery of Aircraft and Personnel) in order to rescue Capt O'Grady. In order to execute the mission, the MEU launched aircraft and a ground recovery team from aboard their ships located in the Adriatic Sea. A TRAP is a mission that MEU(SOC)s specially train to prior to conducting a shipboard deployment. Despite the specialized training needed for a TRAP mission, the fundamental skill sets are similar to those needed for any company level air-assault mission. By analyzing the O'Grady rescue, this paper will then look at how prepared the Marines would be to accomplish this mission in the future.

The 1995 rescue mission required two CH-53 heavy lift helicopters, two AH-1 assault helicopters and two AV-8B attack jets. All these systems are organic to a present day MEU and reside within the Air Combat Element (ACE). To support the ACE, Navy and Air Force assets based in Aviano Air Base, Italy were called in to fill critical roles in the mission. One of the supporting missions was the Suppression of Enemy Air Defense (SEAD). Specially modified F-16s with anti radiation missiles plus dedicated electronic attack aircraft like the EA-6B and EF-

111* comprised the SEAD package. None of the ACE's organic aircraft were even capable of carrying anti radiation missiles or offensive jammers.

The significance of SEAD to overall mission success is captured in statements made by the ACE intelligence officer; "When you have an integrated air defense, you've got to go with the SEAD package. If we had something that was maybe a ground fire threat, just small arms or a man-pad threat, then maybe we could go without the SEAD package if they can't get it put together. But in an integrated air defense environment, that's pretty much a No-Go criteria."[14] The availability of additional aircraft to take on these responsibilities was due to US/NATO involvement in Operation Deny Flight missions originating from nearby Aviano, Italy. Is should not be a foregone conclusion that a MEU will be able to leverage the capabilities of so many aircraft with so much capability.

ACE REQUIREMENTS

In 2025, this mission will have to be executed by MV-22s and Joint Strike Fighters. It is conceivable that the ACE rescue package composition will be similar in size regarding number of aircraft involved. The F-35's would have the requirement to conduct the air defense mission, close air support mission, deep air support mission and SEAD mission. The ability to do all of the missions simultaneously and effectively is debatable. The first concern is one of simple mathematics. The new LHAs will be capable of carrying ten F-35s. Depending on the range and duration of the mission, the aircraft would have to be spread out in order to provide coverage from start to finish. The F-35 design specifications require its ability to fly 1.5hr missions. Assuming an 80 percent readiness level (due to maintenance etc.) that leaves 8 jets ready to fly

* The USAF retired the EF-111 from service in 1998 and has since relied upon US Navy 'expeditionary' EA-6B squadrons (three EA-6B squadrons not assigned to carrier air wings)

on any given day. Of those eight, six or seven would be configured for the mission and the remaining one or two would serve as backup spares. A three hour mission would rapidly deplete the ACEs capabilities.

Aside from asset limitations, mission profile is the second concern. At least with current weapons and tactics, the physical locations of the JSF's to complete all three tasks are not compatible. The number of JSF's available with the MEU would result in an aircraft shortage when flowing out the conduct of all the missions required. SEAD missions in Kosovo were normally accomplished by division sized (four jet) formations of F-16CJs.[15] F-35 contractor, Lockheed Martin, has expressed concerns as to whether a single seat EW variant is possible and the U.S. Navy is concerned about pilot workload while executing SEAD missions in the F-35.[16] Increasing the number of JSF's aboard ship is a physical and logistical limitation so any solution would either require a smaller aircraft, a second flight deck, or a nearby airfield.

The best solution for organic support would be the existence of an unmanned platform that was capable of collecting on the electronic order of battle (EOB). This collection would allow friendly forces to map the locations and operating frequencies of any operating IADS components (Radars, SAMs, Aircraft, Communications) thus providing mission planners the choice to either avoid, minimize or suppress the threats present. A platform with persistence would provide friendly forces indications and warnings (I&W) of operating threat frequencies during real-time execution which would have increased importance when combating mobile, autonomous systems. By operating close to the battlefield, the Marine Corps would have an asset capable of intercepting low energy signals not detectable by national level, overhead assets. If multiple vehicles could be employed and controlled in the same area, signal triangulation could be improved (providing more precise threat locations) and possibly the ability to distribute

SEAD weapons for on-call suppression within the battle space. Other desirable capabilities would be a multi-sensor UAS that could provide video ISR in conjunction with the I&W mission. Assuming that an acceptable launch and recovery system can be devised, unmanned systems would be an excellent asset in filling these support roles to the MAGTF.

The speed and range of the MV-22 will make the MEU ACE a more capable and more viable option for theater commanders than the CH-46 provided in the past. This capability is likely to lead those commanders to conduct operations in locations farther across hostile beaches than we have seen before. As a result, our EW capability must be just as dynamic and far reaching. That capacity, along with the Commandant's vision for a more expeditionary force almost mandates that an organic EW capacity must reside aboard expeditionary shipping. Presently, the EA-6B does not provide the MAGTF commander with the responsiveness and expeditionary capability that he will need for these future tasks. Likewise, USMC Tier III unmanned systems have not yet developed acceptable methods for launching and recovering aboard ship. A viable electronic attack replacement must be able to operate in this environment.

NEW SYSTEM EW LIMITATIONS

MV-22 OSPREY

As the Marine Corps fields new systems, aircraft self protection equipment (ASE) capability must be assessed in order to determine external supporting electronic warfare requirements. One of these systems is the tilt-rotor MV-22 Osprey. As part of the Aviation Transition strategy, all fifteen CH-46 medium lift helicopter squadrons will convert to MV-22s within the next ten years.*

* Four CH-46 squadrons have completed transition to MV-22s as of Jan 2009.

The MV-22 has deployed to a combat theater fielding self protection equipment to include the APR-39A/B(V)2 Radar Signals Detecting Set, the AAR-47(V)2 Missile Warner and the ALE-47 expendables dispenser. In an April 2007 Pentagon press conference the Marine Corps Deputy Commandant for Aviation stated the "The V-22 will be able to fly above the threat [of missiles, small-arms fire, and RPGs]. It also has all the survivability equipment that's required."[17] While not untrue for Iraq or even Afghanistan, these statements would not hold up in locations like Iran or China or North Korea. Even 1970's era RF SAMs, like the SA-2, would pose a threat to the Osprey.

Because the MV-22 is replacing the CH-46 in the aviation inventory it is understandable that one would view threats from the perspective of a helicopter pilot. Threats to helicopters usually consist of short range, medium to low altitude ballistic projectiles (small and medium caliber rockets and guns) and infra red guided missiles. Unfortunately, because of the MV-22s vastly superior flight performance, a whole new set of threat weapons must be considered. MV-22 tactical training, like that conducted at the Marine Aviation Weapons and Tactics Squadron (MAWTS) indicate that flight profiles will be much higher in altitude and will range deeper across the battlefield than helicopter pilots have traditionally done. In fact, the Commandant recently stated that the Marines "need to stop thinking about the Osprey as a helicopter."[18]

Low altitude terrain following tactics that would normally afford a slow flying helicopter a sanctuary from radar guided missiles is not a viable option for the Osprey. It is important to note that Osprey pilots in Iraq do not have to contend with even the simplest of radar guided SAMs. Systems such as the SA-6, SA-8 and SA-15 are all highly mobile, lethal to medium altitude aircraft and widely proliferated to countries like Iran, Syria, and Pakistan. Organizations like Hezbollah have shown how willing these countries are to supply weapons to non state

actors[19]. Even relatively small scale crises like the recent invasion of South Ossetia, Georgia saw Russian armored vehicles and troops escorted by tactical RF SAMs. Many of the break-away Soviet republics posses advanced RF SAMs. Every country that boarders Djibouti, the hub of Marine activity in the Horn of Africa, possesses RF SAMs.

SEABASING AND EXPEDITIONARY VEHICLES

Over the years in both Iraq and Afghanistan, ground vehicles have received ever increasing attention to equip them with counter-radio controlled IED electronic warfare (CREW) systems. The effectiveness of remote controlled, improvised explosive devices (RC-IEDs) has exposed a severe weakness in the protection of ground combat vehicles. The IED threat should be expected to be encountered in any hostile country from now on. Vehicles in development, such as the Expeditionary Fighting Vehicle (EFV), are presently not equipped to counter any RF threat system. The EFV will be "the Marines primary means of tactical mobility . . . during the conduct of amphibious operations ashore."[20] Scheduled to begin operational service in 2015, the EFV is intended to provide Marines greater range and speed than the amphibious assault vehicle provides today. Even if equipped with a CREW device, the EFV is not capable of countering a missile or radar. The aged CH-46 has better missile defense capability than does the $22 million EFV carrying 20 Marines. Both the MV-22 and the EFV are designed to provide the Marines with a 'farther-faster' capability over existing Marine vehicles. The speed and flexibility to conduct over the horizon movements is intended to surprise and out maneuver our enemy. An enemy determined to counter a sea-borne attack could utilize its coastal defense radars to detect approaching vehicles. Missiles equipped with RF seekers could target any seaborne vessels approaching. On the open ocean, an aircraft flying as low as 200 feet can be detected on radar at

17 Nautical miles. Elevating that radar to 38 feet increases the detection range out to 25 nautical miles* which is the minimum distance a Navy ship will close to an enemy coastline for self protection purposes.[21] Would it not be logical for our enemy to recognize his own vulnerability to these systems and seek ways to counter them? Without too much imagination or training, a country like Iran could load their cold war era attack jets with RF guided, anti ship missiles to attack both the amphibious ships and even the individual assault vehicles. Iran has an extensive coastal defense network and any air or sea launched attack would be challenged to achieve surprise against a defender. Without organic self protection equipment designed to counter RF threats, these assault vehicles could literally be dead in the water.

In this scenario, a platform capable of dispensing a radar cluttering screen of bulk chaff and/or RF jamming of coastal surveillance radars and communications would greatly enhance survivability. If the assault vehicles cannot protect themselves, an escort vehicle must do the job for them.

On 21 July 2006, the Israeli Navy was shocked when one of their corvettes was attacked and severely damaged by an anti ship missile.[22] The reason they were shocked was because Hezbollah, a non-state actor, had utilized a large, sophisticated, RF surface to surface missile known as a C-802 (supplied by Iran). This incident should serve as a warning that non-state actors are not restricted to AK-47s and RPGs as their only means of attack. Technology once thought to reside only at the state level is now being proliferated by terrorist organizations and we should not take their technical aptitude for granted. In opening statements made in July 2008 to the House Armed Services Committee, VAdm McCullough commented that these threats

* Radar horizon formula $= 1.23\left(\sqrt{h_1} + \sqrt{h_2}\right)$ where R is the range in nautical miles, h_1 is the aircraft height in ft, and h_2 is the radar antenna height in ft.

"will require us to continue to improve our blue water . . . anti-ballistic missile capabilities in order to counter improving anti-access strategies."[23]

We know that Iraqi insurgents utilize their cellular network, long range cordless telephones and commercial satellite phones for command and control as well as RC-IED triggers. Commercial, off the shelf wireless technology is advancing at a rate that is difficult for us weapons programs to counter.

EW TARGETING

The 1999 Kosovo air war demonstrated just how difficult it was for SEAD assets to locate tactical, mobile RF-SAM systems. [24] Mobile threats operating in mountainous terrain and operated by disciplined radar operators who minimized radio transmissions were exceptionally hard to locate. "When you have a lot of unlocated threats, you are at risk even in a stealth airplane."[25] Knowing where the threats are is the first step to avoiding getting shot down. Part of the electronic warfare support mission of the EA-6B is to localize enemy threat systems and update the electronic order of battle as a means of updating the locations of enemy radars and associated weapons. Under the best of circumstances, this can be a tedious, time consuming process. From the SCUD hunts of Desert Storm, the SA-6 hunts of Allied Force and now the manhunts in Iraq and Afghanistan, target location can be challenging. With the demise of the EA-6B, position location of RF signals should be franchised out to all TacAir, Assault support and UAS platforms. Since no single system is likely to have the availability to be dedicated to conduct ES, a network of systems could prove to be more capable than any one platform. If cleverly employed, a system like the SA-8 hidden in the urban environment of Iraq would pose a serious threat to coalition aircraft of all types. But different platforms at different altitudes and

mission profiles could rapidly locate an active threat and avoid, suppress or target as appropriate. It is believed that the Hezbollah anti ship missiles were fired from the backs of pick-up trucks which are mobile, easily concealable and give little to no warning prior to launch.

Another lesson of Kosovo was that US technology is not flawless. In 1999, an F-117 was detected by 1960's technology and shot down by an SA-3 over the skies of Yugoslavia. This marked the first combat loss of a low observable (stealth) aircraft due to hostile fire. The critical reviews of this incident, which included congressional hearings, had USAF Air Combat Commander Gen. Richard Hawley stating; "Stealth airplanes aren't invisible. They are designed to reduce the lethal envelope of enemy air defense systems, not eliminate them."[26] The low observable characteristics of the F-35 help to mitigate the RF threat but it does not eliminate it entirely. If a similar attitude of technological superiority and violation of established TTPs prevails in our employment of either the F-35 or MV-22, we will suffer the same consequences as the F-117 did in Kosovo.

CONCLUSION

The three factors in shaping a viable EW solution are threat, capability and platform. The future platforms for the Marine Corps have already been decided and they truly are very capable systems. The shortcoming is in evaluating the threats we face with our new capabilities. The ability to provide airborne electronic fires to support Marines conducting aviation, amphibious and ground operations is in jeopardy if the Corps does not honor the full spectrum of threats facing us across all dimensions of the battlespace. The high end RF threat systems will be just as relevant to the MAGTF in the future as off the shelf radio technology has been in the present. While the ground RF threats in Iraq and Afghanistan exposed vulnerability in our ability to

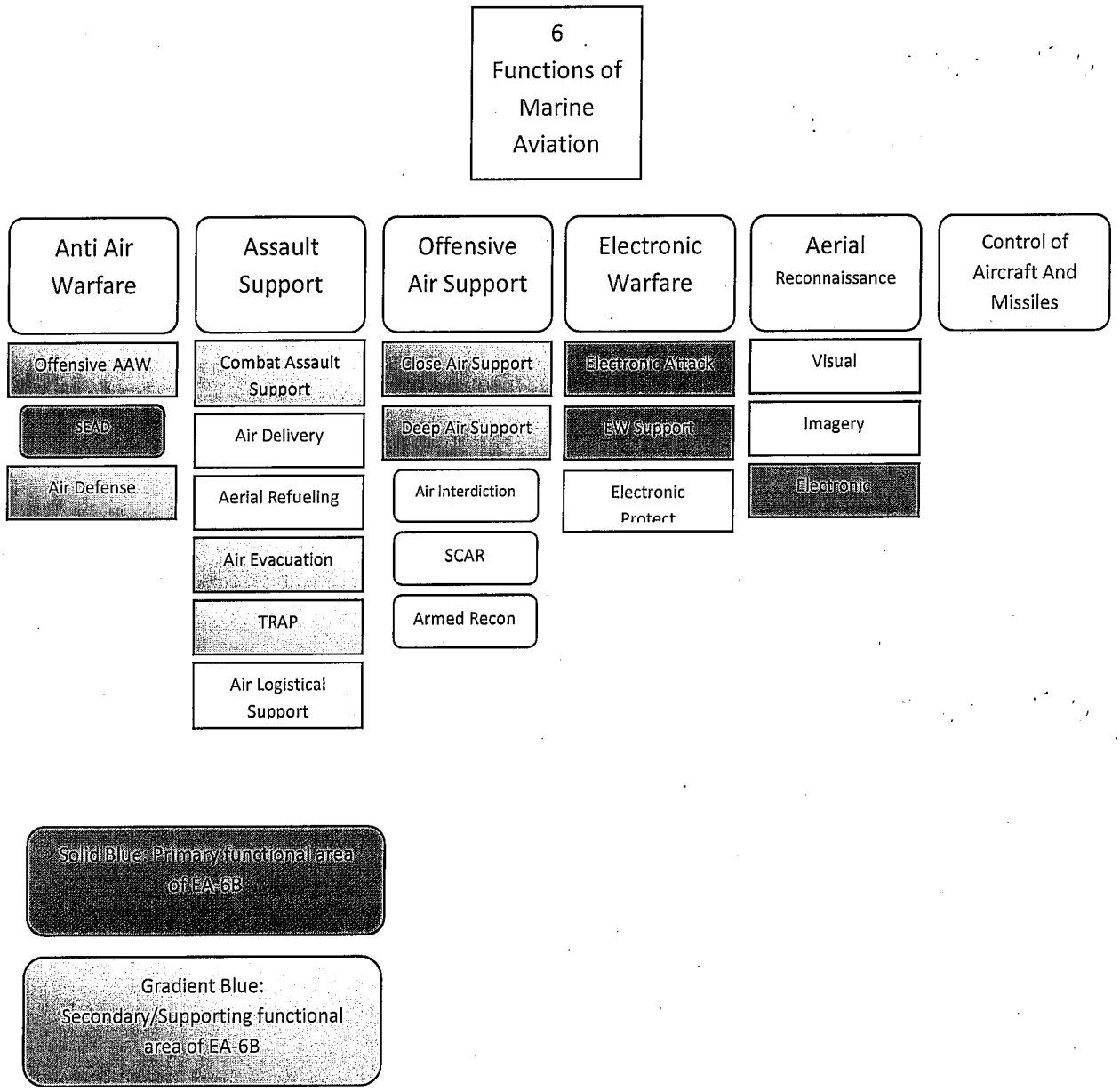
influence the electromagnetic spectrum, none of these threats were relevant until U.S. forces became involved in slow, protracted, police-type activity and counter insurgency operations (COIN).

The Commandant's vision for the Marine Corps desires little involvement in these types of missions. Rapid response, forcible entry and minimum footprint ashore will be the characteristics the 2025 Marine Corps. This cannot be adequately supported by slow, short range, low power jammers mounted on UAS's. It is much easier to hit someone lightly with a big stick than it is to hit him hard with a little stick. For four decades, Prowler jamming was that big stick. Marine EW has had to refine its application over the years, but we always had the power necessary for the mission. By focusing too much on distributed, low powered systems we are denying ourselves the ability to effectively counter existing and emerging RF threats that could hurt us even before we get Marines ashore.

The January 2009 decision by the Commandant to have the F-35 fitted for Next Gen Jammer is a huge step in acknowledging this requirement. Future jammer technologies are part of the solution, but recognizing that a spectrum of high and low end RF threats face all elements of the MAGTF is key to understanding our EW needs. Initiatives for a multi platform, networked approach will ensure Marine success if we properly honor the threat. The transition to new platforms and a return to a sea-based, expeditionary nature have made the requirement for a robust airborne electronic attack capability just as important as it has ever been in Marine history.

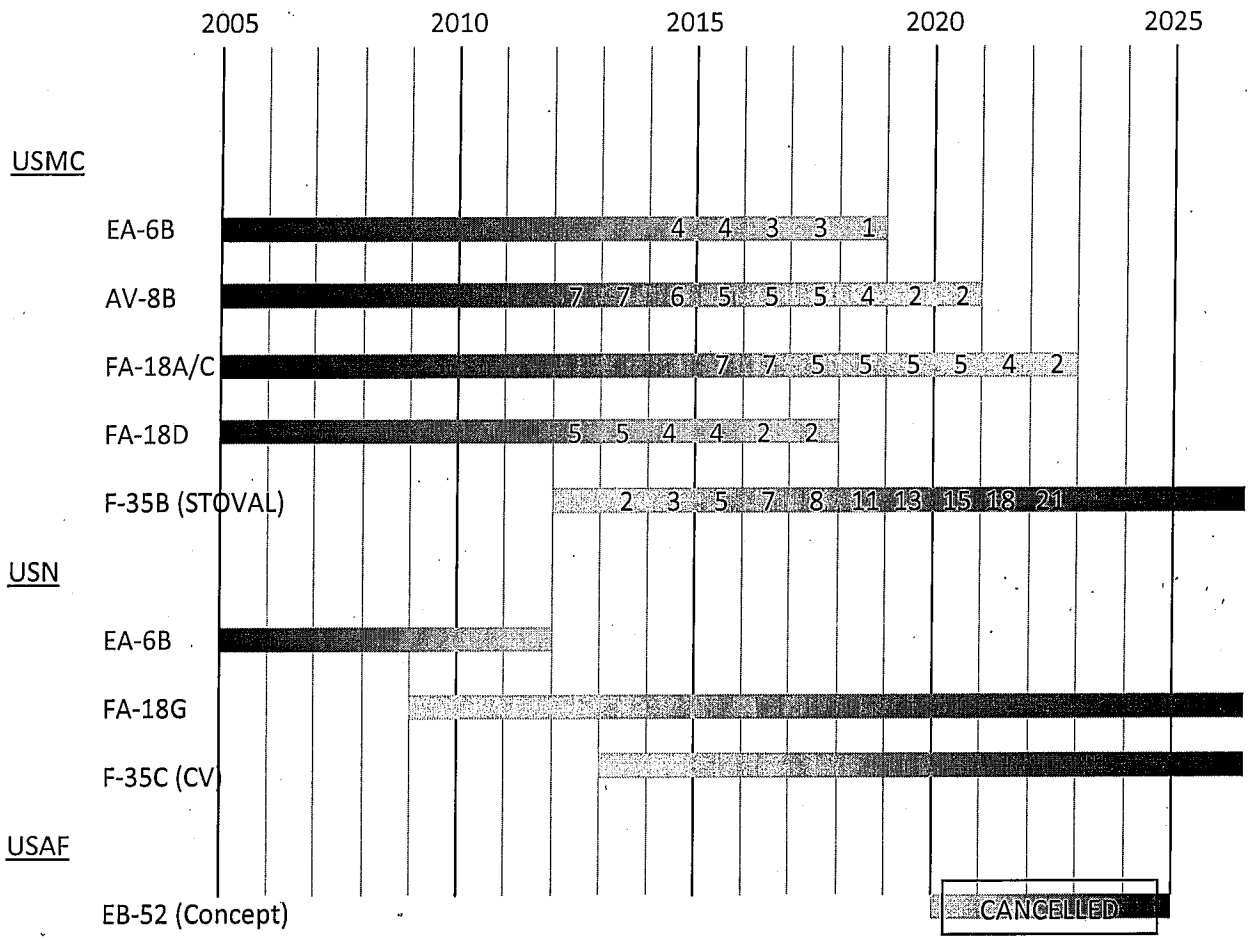
APPENDIX A

Functions of Marine Aviation



APPENDIX B

Airframe Timeline/ Life Expectancy

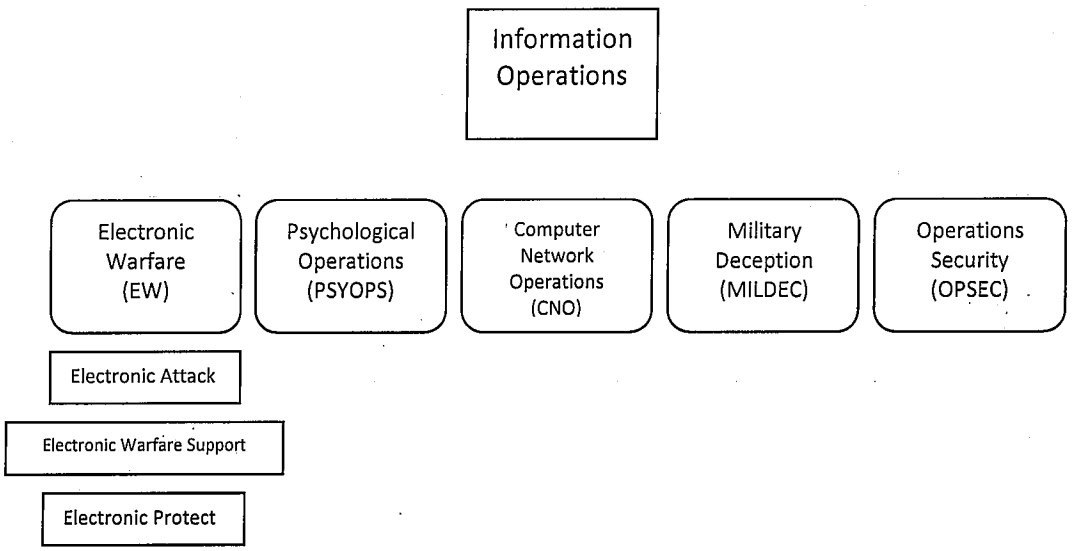


USMC Data derived from the 2009 Aviation Campaign Plan.
USN Data derived from *Naval Aviation Vision 2020.*

Numbers listed within timeline bars represent projected number of operational squadrons per year.

APPENDIX C

Functions of Information Operations



APPENDIX D

Aircraft Performance Specifications

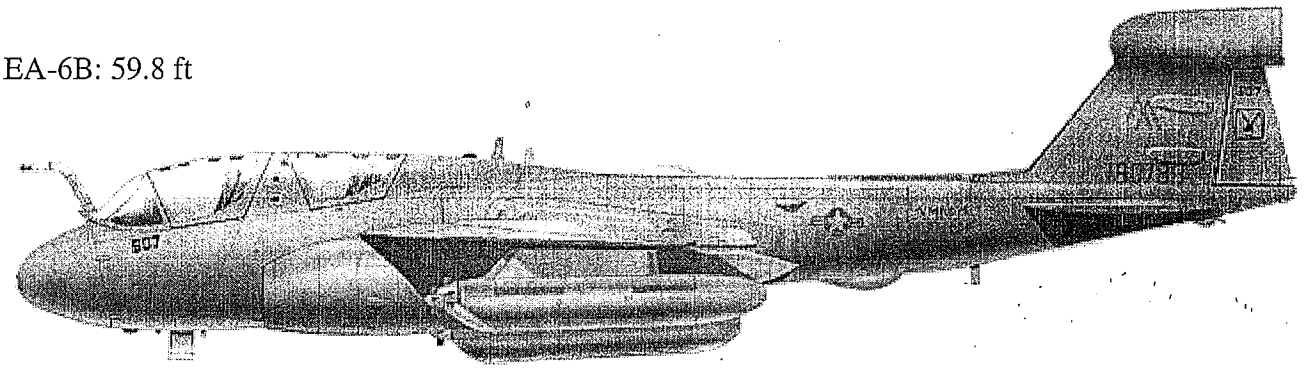
Platform	Speed Max/Cruise (kts)	Unrefueled Range (NM)	Unrefueled Endurance (Hrs)	Operational Altitude (Ft)	Payload Internal/external (Lbs)	Ship Deployable
EA-6B	550/420	1,000	3.5	20k	0/12,000	Yes
F-35	1,200/ 480*	900	1.5*	+30k*	3,000/15,000	Yes
KC-130J	360/350	2,800	8	25k	42,000	No
RQ-14 Dragon-Eye	60/35	3	1	500	<5	n/a
RQ-7 Shadow	100/60	27	6	15k	60/0	No
MQ-9 Reaper	240/160	3,200	30+	50k	800/3,000	No

*indicates estimated numbers based on unclassified data

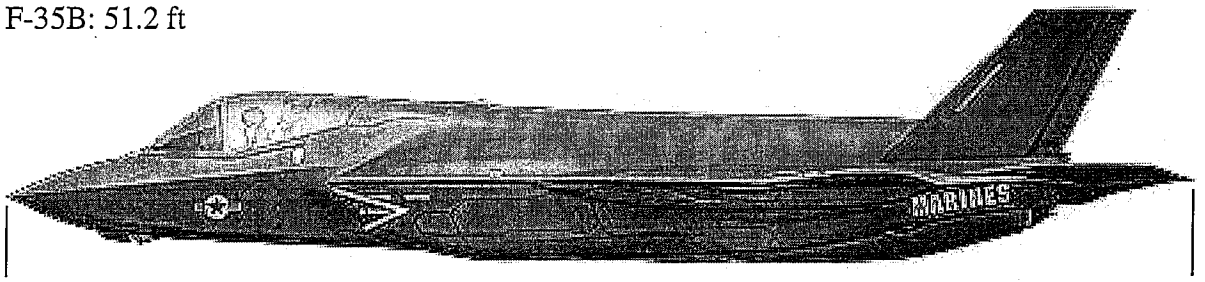
APPENDIX E

Size Comparison Chart

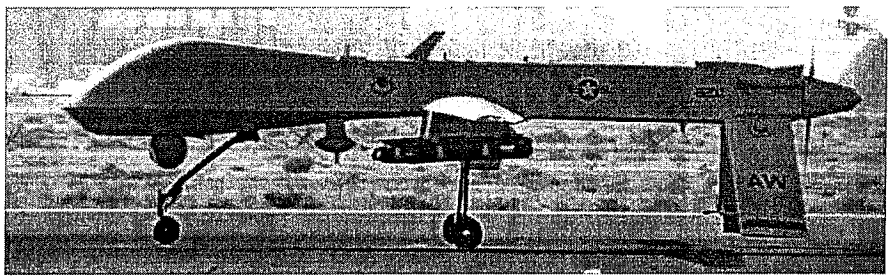
EA-6B: 59.8 ft



F-35B: 51.2 ft



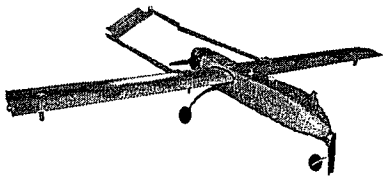
MQ-9 Reaper: 37ft



ALQ-99 Tactical Jamming Pod: 15.4 ft

AGM-88 Anti Radiation Missile: 13.6 ft

Shadow-200: 11 ft
(Tier III)



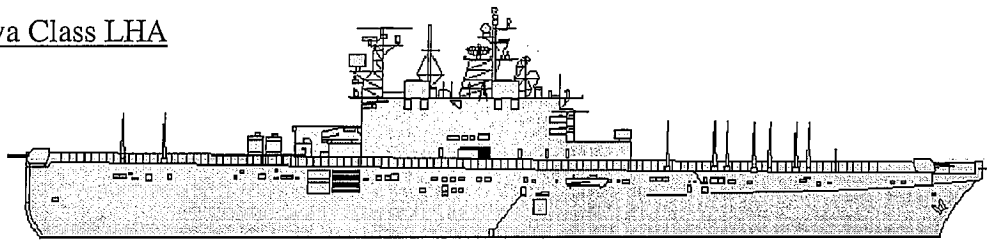
Scan Eagle: 4 ft
(Interim Tier II)

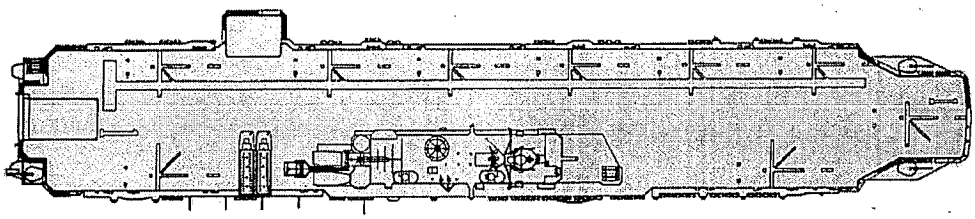
Dragon Eye: 3 ft
(Tier I)

APPENDIX F

MEU ACE Comparison

Tarawa Class LHA

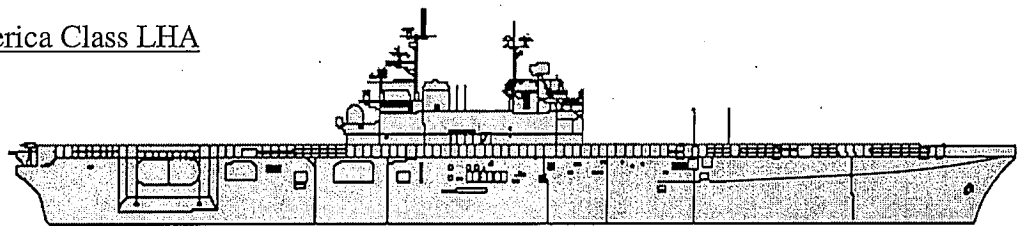


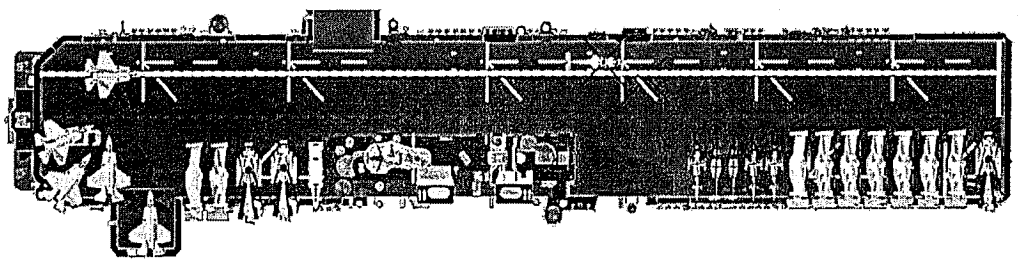


Present ACE Configuration:

AV-8B	CH-46	CH-53	AH-1	UH-1
x6	x12	x4	x4	x3

America Class LHA





Proposed ACE Configuration:

F-35	MV-22	CH-53	AH-1Z	MH-60
x10	x12	x4	x8	x4

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